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Possible Regulatory Effects of Coalition Computations on the Mu Rhythm

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ABSTRACT PAGE

Evolutionary psychology has demonstrated that the quick and effortless categorization of an individual's race is a by-product of cognitive adaptations designed by natural selection to track coalition affiliations. Furthermore, two key inputs tend to maximize the categorization of individuals into coalitions: (1) patterns of cooperation and (2) corresponding shared appearances. The current studies attempted to explore possible regulatory effects that coalitional computations have on the mu rhythm – an electrophysiological phenomenon implicated in a wide range of social cognitive processes. Results indicate that these computations have no significant regulatory effects on the mu rhythm in the passive viewing of racial outgroups, as well as a competitive scenario between established coalitions. Limitations are discussed along with implications for both the coalition literature and the functioning of the mu rhythm.

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Possible Regulatory Effects of Coalition Computations on the Mu Rhythm

As humans navigate their social world gathering information to guide behavior, they often begin by forming impressions of others (Fiske, Lin, & Neuberg, 1999). This process is conventionally termed "person perception" and is reported as occurring quickly (Banaji & Hardin, 1996; Dickter & Bartholow, 2007; Zarate & Smith, 1990) and effortlessly (Fiske, 1998), often leading to the categorization of individuals based on visually prominent features (Brewer, 1988; Fiske, 1998). Furthermore, social psychologists continue to discover that the categories of sex and race tend to be identified easily (Fiske et al., 1999) in less than a second upon viewing an individual (Dickter & Bartholow, 2007; Ito & Urland, 2003), often leading to the activation of stereotypes (Bartholow & Dickter, 2008) and nonverbal biases (Weisbuch & Ambady, 2008).

Kurzban, Tooby and Cosmides (2001) have extended these findings by demonstrating that the cognitive mechanism used to categorize race likely evolved to detect and track coalitions, not race per se. Furthermore, it has been suggested that this coalition mechanism is optimized to process (1) patterns of cooperation and (2) visual cues corresponding to these patterns (Kurzban et al., 2001). Although there is evidence of nonverbal "biases", behavioral acts that contribute to communication in social interactions (i.e. failure to mimic facial expressions), as a result of coalition detection (Weisbuch & Ambady, 2008; Hugenberg & Bodenhausen, 2004), it is unknown how the coalition mechanism regulates these nonverbal biases. A well documented psychophysiological phenomenon, the mu rhythm, is thought to provide a necessary antecedent of many nonverbal behaviors (Pineda, 2005), making it an ideal candidate to

be regulated by the coalition mechanism. To bridge this gap, the current studies will explore the possible regulatory effects that coalition computations have on the mu rhythm.

The literature review below is structured in the following way: (1) the theoretical framework, (2) race or coalitions, and (3) the mu rhythm. Therefore, the first section will be a proper review of the theoretical framework, often called evolutionary psychology. Next, the social psychological phenomenon surrounding person perception will be reviewed in terms of the evolutionary psychology framework previously discussed. Finally, the incorporation of embodied social cognition into the evolutionary framework will introduce the mu rhythm as a psychophysiological phenomenon crucial to the production of nonverbal social behavior (Pineda, 2005). This will ultimately lead to the hypothesis that the cognitive mechanisms evolved to detect and track coalitions, might regulate the desynchronization of the mu rhythm, providing for a potential neurophysiological basis for nonverbal "biases".

Modern Evolutionary Theory

> "Nothing makes sense in biology except in the light of evolution." (Dobzhansky, 1964, pp. 449)

The complexity of the brain/mind and the enormous variability in human behavior is a rather impressive and humbling phenomenon to consider, but with a proper understanding of natural selection, the underlying order of this complexity and variability can be revealed (Tooby & Cosmides, 1992). What follows is an overview of natural selection which will bring to the forefront three important principles of evolutionary

psychology that will be applied throughout the current research.

The overview will (1) demonstrate the basic logic behind natural selection, (2) extend this with a discussion of inclusive fitness, and (3) define the three products of natural selection: adaptations, by-products, and noise. These basic concepts will then be applied to the brain/mind and human behavior, highlighting three important principles of evolutionary psychology that will be applied in the current research.

Natural Selection. The process of natural selection is capable of generating functional complexity by utilizing existing variability within a phenotype to solve a specific problem faced by the organism in possession of the phenotype (Dawkins, 1986; Buss, Haselton, Shackelford, Bleske, & Wakefield, 1998). These phenotypes are inherited traits that arise from the interaction between developmental programs specified by the genotype and necessary environmental inputs, making successful reproduction critical to the selection process (Tooby & Cosmides, 1990). As the variability in a given phenotype interacts with a particular aspect of the environment, a subset of the versions in the given phenotype may allow the organism an advantage in the rate of survival, and thus reproduction. More successful reproduction often increases the frequency of the versions of a phenotype that initially allowed for an advantage in the organism's survival and reproduction, creating a positive feedback loop. Over evolutionary time, if the specific problem that elucidated functional differences between the versions of a phenotype reliably recurs, the differential propagation of the most successful phenotypic designs will emerge as a species-typical trait. On a larger scale, where multiple phenotypes interact with multiple environmental problems, an array of complexly organized,

functionally distinct species-typical traits emerges (see Darwin, 1859/1958; Dawkins, 1976, 1986).

For example, the complex functional organization of the human eye emerged through successive iterations of natural selection. One can imagine a variety of co-existing cells, some sensitive to changes in pH, others sensitive to electrochemical gradients, and others sensitive to changes in illumination. Individuals within a species in possession of the light-sensitive cells were capable of detecting shifts in light generated by other moving objects, and in particular – predators. Over evolutionary time those individuals equipped with the light-sensitive cells received an advantage in survival, and thus out-reproduced those organisms without the light-sensitive cells. Next, as these light-sensitive cells begin to form membranes, a variety of shapes likely existed, in which some may have been straight, while others were curved. In fact curved light-sensitive membranes begin to focus light, generating the initial forms of a lens. Again, this curved design affords the individuals in possession of it a survival or reproductive advantage, leading to the differential propagation of this phenotypic design. Over evolutionary time, additional solutions to survival and reproductive problems may be solved by versions of the light-sensitive membranes, eventually leading to the human eye. This constant gradation propelled by functionality, ultimately leads to organized complexity, which could not have emerged by chance alone (Dawkins, 1976, 1986). Although this conceptualization of natural selection is adequate in understanding the emergence of the eye, it cannot explain the emergence of many behaviors emitted by organisms that reduce their own rates of survival and reproduction (Dawkins, 1976).

Inclusive Fitness. To address this issue, Hamilton (1964) proposed the idea of inclusive fitness. Hamilton (1964) suggested that successful reproduction by an individual is not the only way a phenotype can increase in frequency within a population. In addition, organisms may emit behavior that enhances the survival or reproduction of close genetic relatives who likely carry the genes necessary to produce some of the same phenotypes (Buss et al., 1998). This insight led Dawkins (1976) to conclude that natural selection operates at the genetic level, because a gene is the smallest piece of organic matter containing information that can reliably be replicated over successive generations. This suggests that it is not the species or individual, but the gene that provides natural selection with the necessary fuel to proceed. In other words, Dawkins (1976) suggests that organisms (including humans) are vehicles of replication for genes, and that the phenotypes produced are tools used by the genes to continue to replicate. To avoid the erroneous "genetic determinism" interpretation of Dawkins' (1986) conclusion, Tooby and Cosmides (1990) state that natural selection acts *through* the genes, but acts *on* the interaction between developmental programs specified by the genes and the environment, highlighting that the genes and environment equally co-determine the phenotypic designs of an organism. Although phenotypic designs interact with recurring problems in the environment ultimately leading to adaptations, not every feature of an organisms is an adaptation.

Adaptations, By-products, and Noise. In fact, the process of natural selection produces a variety of effects that can be organized into three classes: Adaptations, by-products, and noise (Buss et. al, 1998; Tooby & Cosmides, 1990). Buss and colleagues

(1998) define an adaptation as "...an inherited and reliably developing characteristic that came into existence as a feature of a species through natural selection because it helped to directly or indirectly facilitate reproduction during the period of its evolution (after Tooby & Cosmides, 1992)." Furthermore, adaptations are typically ubiquitous within a species' traits, with a few exceptions, but are not necessarily present at birth, nor free from environmental influence (Buss et. al, 1998).

The second class of effects produced by the evolutionary process is by-products. By-products are features or characteristics that do not contribute to solving an adaptive problem, but are reliably inherited because they are a property of an adaptation. An example of a by-product is the apparent whiteness of bones. Bones were selected for because high concentrations of calcium provided the necessary strength required to support and protect an organism, but because high concentrations of calcium appear white, bones tend to be white (Buss et. al, 1998; Symons, 1992).

The last product of the evolutionary process is genetic noise. Variability in the genotype emerges by genetic drift, mutations or pathogen driven co-evolution of biochemical diversity. In each scenario, the variations in the genotype may present superficial variations in the phenotype, some of which interrupt the functioning of the organism, while others remain benign. An example of genetic noise is the variations within humans on the shape and size of their stomachs. Although there is variability on the shape and size of human stomachs, this variability does not compromise the functional integrity of the organ. The importance of genetic noise, however, is that it introduces phenotypic variability which is precisely what natural selection needs to solve

future adaptive problems (see Tooby & Cosmides, 1990).

In sum, by making the process of natural selection explicit during empirical investigations of the brain/mind and human behavior, the underlying order of its immense complexity may be revealed. However, given the conceptual framework discussed thus far, it may appear difficult or irrelevant to apply to human psychology. As it turns out, a number of scientists have already successfully applied the logic of natural selection to human psychology generating a number of crucial insights into human nature, three of which will be applied explicitly in the current research. These three key principles deal with (1) adopting a functional perspective when studying the brain/mind, (2) the nature of the cognitive adaptations that comprise the brain/mind, and 3) the physical instantiation of these adaptations in relation to their function.

Evolutionary Psychology

Just as the eye is an organ shaped by natural selection to solve recurring adaptive problems, so too is the brain. Ignoring this fact has led many social sciences to be "adrift" in search for answers about human nature -- producing a compilation of descriptions and proximate explanations at best, while simultaneously isolating the study of the human mind from the natural sciences (Tooby & Cosmides, pp. 23, 1992).

With a proper understanding of natural selection several predictions about human psychology emerge that should be seriously considered when investigating any psychological phenomenon. Three of these predictions will serve as the principles guiding the current investigation. First, questions regarding functionality are central to understanding human nature. Second, the brain/mind contains an array of functionally

autonomous content-dependent, information-processing units, or cognitive mechanisms. Lastly, these cognitive mechanisms are physically instantiated as neurons, glial cells, and astrocytes, yet the location of their instantiation is only important insofar as the functionality is not compromised, making the brain and the mind different perspectives on exactly the same physical substance (Tooby & Cosmides, 1992).

Functionalism. In recent years, the field of psychology has seen a growth of interdisciplinary approaches reflecting the desire to explore phenomena at multiple levels of analysis (i.e. cultural, neurological). Although these approaches provide a unique perspective on any given psychological phenomenon, they are not capable of transcending all other levels of analysis and providing ultimate explanations. Once a field discovers the level of analysis that can thoroughly unravel the immense complexity of their topic -- the level that allows for the highest resolution of insight into the underlying order -- it begins to make great strides in scientific discovery (Tooby & Cosmides, pp. 63, 1992). From an evolutionary perspective, the most logical and promising level of analysis is that of functionalism.

Ermer, Cosmides, & Tooby (2007) define the function of a biological mechanism as "the problem it solved -- the consequences it had -- that caused the propagation of its genetic basis relative to that of alternative mechanisms" (p. 153). This approach has been informing biologists for decades now, and in particular, anatomists have successfully carved the human body at its joints (Buss, 1995). For example, the heart functions to circulate blood throughout the body, whatever its proximity to, or similarity in appearance with the lungs or the liver, it is considered a distinct organ because of its

distinct function. By utilizing the functional level of analysis, anatomists and physicians are well-equipped to make predictions about which variables will or will not affect the heart. Similarly, to "carve" human psychology "at its joints" the functional level of analysis is thought to be necessary (Tooby & Cosmides, 1992).

From the standpoint of evolutionary theory, the functional level of analysis logically follows because the existence of an adaptive biological mechanism is dependent upon its functional success, or its ability to enhance its own propagation (Tooby & Cosmides, 1992). Although the same biological mechanism may be described from multiple perspectives, understanding the adaptive problems it solved will reveal its underlying order. This does not leave some features of a complex biological mechanism unexplained, rather it provides the necessary frame of reference to being unraveling which features are necessary for the mechanism to function, which are by-products, and which are random variations. For example, the function of the heart is to pump blood, therefore features such as valves and chambers contribute to its function, while the red appearance the heart takes on is simply a by-product of the material used to make the valves and chambers. Without starting with the function of a complex biological mechanism, there is no way to predict which features, when manipulated, will alter the outcome. Furthermore, the function of a biological mechanism may be realized on multiple levels (i.e. chemical, individual, cultural), but only the functional level is capable of transcending these alternative levels of analysis to provide ultimate explanations for organized complexity.

Broadly speaking, a functional level of analysis suggests that the brain/mind

functions as an information-processing unit, to guide an organism's behavior in adaptive ways *on average* (Tooby & Cosmides, 1992; 1995). However, knowing that the brain/mind had to solve an *array* of problems, each of which shaped its design, evolutionary theory further suggests that the brain/mind is comprised of several *domain-specific content-dependent* cognitive mechanisms (Cosmides & Tooby, 1994; Tooby & Cosmides, 1992).

Cognitive Mechanisms. The process of natural selection, although powerful enough to engineer complex functionally organized biological mechanisms, does so without any of the advantages a human engineer possesses (Tooby & Cosmides, 1992). That is, natural selection does not have any foresight and it cannot start from scratch each generation (Dawkins, 1976; 1986). Over evolutionary time, phenotypic designs interact with the environment, encountering both old and new adaptive problems that must be solved with whatever phenotypic designs happened to have made it up to that point. Without foresight, or an end goal, natural selection is not capable of designing a biological mechanism to solve a problem in the future; rather it only determines the propagation of a phenotype based on how well that phenotype solves current adaptive problems. Resulting from this lack of foresight and inability to start from scratch are multiple biological mechanisms, each well-equipped to solve the specific recurring adaptive problems that shaped its design (Tooby & Cosmides, 1992).

Traditionally, psychologists and neuroscientists have argued for a domain-general or all-purpose learning conceptualization of the brain/mind, typically due to the observation that the human intellect is extremely flexible, citing classical and operant

conditioning studies for support. However, theoretically informed empirical evidence appears to suggest that the brain/mind is comprised of domain-specific cognitive mechanisms designed by natural selection to optimally, but by no means exclusively, process the information that was necessary to solve the recurring adaptive problems that shaped it (Duchaine, Cosmides, & Tooby, 2001; Gallistel & Gibbon, 2000; Hirschfeld & Gelman, 1994; Tooby & Cosmides, 1992).

Considering the constraints placed on the process of natural selection in conjunction with the need to solve multiple adaptive problems within a generation, a domain-specific view of the brain/mind logically follows. First, consider the fact that an organism faces multiple adaptive problems, many of which require very different computations. For example, the computations necessary to interpret the 2-D retinal display as a 3-D scene requires the use of Bayesian probability (Pinker, 1997, pp. 243), yet the computations necessary to detect a cheater require conditional logic (Cosmides, 1989). Neither system is capable of reliably solving both problems, so natural selection could not have used the same computations in both scenarios. Instead natural selection would have had to build in another sub-routine, or mechanism, to perform both sets of computations, making the system domain-specific and inherently more flexible (see Tooby & Cosmides, 1992).

Proponents of the domain-general view often suggest that domain-specificity cannot account for the phenomena of classical and operant conditioning, instead purporting an association model (Duchaine et al., 2001). However, Gallistel and Gibbon (2000) have demonstrated that classical and operant conditioning is best captured by

domain-specific mechanisms designed by natural selection to compute future uncertainties while foraging. These mechanisms use multivariate nonstationary time-series analyses to predict many of the intricate conditioning phenomena that association models have failed explain (Duchaine et al., 2000).

Empirical evidence of domain-specificity is not confined to conditioning, but is evident in face recognition (Kanwisher, McDermott, Chun, 1997; Kanwisher, 2000; McCarthy, Puce, Gore, & Allison, 1996), language acquisition (Pinker, 1984, 1989), self-esteem (Kirkpatrick, Waugh, Valencia, & Webster, 2002), vision (Marr, 1982), and perception (Proffitt & Gilden, 1989), to name a few (see Tooby & Cosmides, 1992, pp. 97). Not only do these findings support a domain-specific view of the cognitive mechanisms that comprise the brain/mind, but they also suggest, if not require, that these mechanisms contain built-in assumptions.

One of the first problems faced by any computational machine, biological or otherwise, is the issue of combinatorial explosion (Tooby & Cosmides, 1992). Combinatorial explosion refers to the fact that as the degrees of freedom within a system's decision repertoire increases, the total number of alternative decisions exponentially grows to staggering numbers (Tooby & Cosmides, 1992). The most striking example of this comes out of the language acquisition literature (Pinker, 2002; Tooby & Cosmides, 1992). After behaviorism failed to properly explain how humans everywhere are capable of acquiring language within a time span too short for operant and classical conditioning, Noam Chomsky introduced the idea of mental organs with built-in rules or assumptions to guide language development (Pinker, 1997, 2002; Tooby & Cosmides,

1992). Chomsky considered that with all of the possible utterances a human can make, the brain must come equipped with assumptions regarding how to structure them in systematic ways, so much so that nearly every language on earth is capable of following one of two main structures (Pinker, 2002). Only by considering a brain/mind equipped with a set of rules or assumptions that reflect the underlying order of the adaptive problems it was designed to solve, was Chomsky capable of explaining language acquisition in the face of combinatorial explosion.

From the point of view of natural selection, cognitive mechanisms with built-in assumptions are the same as any slight modification made to a phenotype to solve an adaptive problem. If there were no selection pressures to rule out alternative designs of the human eye, it is likely that eyes would merely be variations of light-sensitive membranes, rather than the extremely complex design we witness today. In fact, if the brain/mind did not contain built-in assumptions, it would suggest that natural selection never filtered out any one particular design of the brain, meaning that the brain would not be capable of accomplishing much of anything (Tooby & Cosmides, 1992). It is apparent, anecdotally as well as experimentally, that the brain/mind can solve an array of complex problems in a very dynamic fashion. Many artificial intelligence, vision, and perceptual scientists have concluded that the brain/mind does in fact contain built-in assumptions, otherwise the computations made by the visual cortex would remain unsolvable, therefore many adaptive problems would remain unsolvable as well (Pinker, 1997, 2002; Tooby & Cosmides, 1992).

Adelson and Pentland (1996) describe how the visual cortex must compute the

luminance of a surface by combining illumination and reflectance. However, the brain begins with the product – luminance – and must infer the shading and reflectance. Adelson and Pentland (1996) explain that this multiplication cannot be unraveled, so the visual cortex must make assumptions about regularities in the natural world. Pinker (1997) uses the example of distinguishing between a lump of coal and a snowball viewed outside and indoors. The visual cortex must assume that the world is equally lit in order to continue to "see" the coal as coal and the snowball as a snowball in both conditions. Without this built-in assumption the problem becomes unsolvable (Pinker, 1997).

Most of the evidence of built-in assumptions can be found in the vision and perceptual sciences, but more examples of the same concept are beginning to emerge elsewhere in psychology. For example, infants exhibit an attention bias to structures that resemble human faces so early in development that experience cannot account for the phenomenon (Morton & Johnson, 1990). In addition, the categorization literature has discovered that infants overwhelmingly categorize objects at their basic level, at which the most information regarding the objects affordances can be revealed (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976), suggesting that there must be some innate set of rules to guide this process. Each and every single computation made by these functionally autonomous domain-specific and content-dependent cognitive mechanisms is physically instantiated in the brain tissue, but ignoring their function and concentrating solely on neural activity may produce misleading ideas about human nature.

Brain/Mind. An age old question in psychology, neuroscience, and philosophy has been the relationship between the brain and the mind. An evolutionary approach suggests

that the mind and the brain are one in the same, with the chemical make-up, cellular structure and neural organization being levels of functional implementation that may be altered by natural selection to successfully produce a cognitive adaptation. However, considering that the cortex is structurally uniform within and between mammals (Rockel, Hiorns, & Powell, 1980) and that the major neurotransmitters cover large regions of the brain, it appears that the intricate connectivity of the neural tissue is the only way to capture the physical implementation of a cognitive adaptation (Rockel et al., 1980). Even if the technology were available to discover the intricate connectivity, it would merely provide a description and not an explanation for a cognitive adaptation. As Marr (1982) suggests, "trying to understand perception by studying only neurons is like trying to understand bird flight by studying only feathers" (Cosmides & Tooby, 1995). Ultimately, the physical properties of the instantiated cognitive mechanisms place rather trivial constraints on the adaptive design because the process of natural selection is concerned with functional success which may be achieved just as well with different neural underpinnings (Cosmides & Tooby, 1995). It may be best to consider the brain as the hardware of a computer, and the mind as the software. For example, it is possible for ten different computers, with different hardware specifications, to successfully install the same word processor application and create *identical* word documents. If one were to "image" the electrical instantiation during the creation of the word document, the resulting patterns may be very different, but the functional result is the same.

Recognizing that the brain is an organ shaped by natural selection allows for an approach to the study of human psychology that can begin to reveal the underlying order

of its complexity. In addition, this perspective leads to several key insights that may be applied to study *any* topic in psychology (Buss, 2005; Tooby & Cosmides, 1992). First, questions regarding function are crucial for revealing the underlying order of the complex brain/mind. Second, the brain/mind is comprised of domain-specific, content-dependent cognitive mechanisms designed by natural selection to solve recurring problems in our evolutionary history. Lastly, these cognitive mechanisms are physically instantiated in the neural and chemical structure of the brain, but the structure is ancillary to its function. Taking this into account, the current research will employ a functional level of analysis to investigate the domain-specific and content-dependent cognitive mechanisms involved in the social psychological phenomenon of racial biases.

Race

Investigations of racial biases in real-world scenarios reveal that Blacks accused of violent crimes were more likely to receive the death penalty than Whites accused of equally violent crimes (Eberhardt, Davies, Purdie-Vaughns, 2006). In simulated real-world environments White participants were significantly more likely to misperceive a tool as a gun when primed with a Black face as opposed to a White face (Payne, 2001), and were significantly more likely to shoot an unarmed Black individual than an unarmed White individual in a computer simulation (Correll, Park, Judd, & Wittenbrink, 2007). These findings have encouraged many researchers to investigate the underlying mechanisms that may give rise to such profound racial biases.

There exist many empirical findings highlighting racial biases; however, the present review will focus on those related to attention, memory, and nonverbal biases. Trawalter,

Todd, Baird, and Richeson (2008) used a dot-probe paradigm to test relative attention between Black male and White male faces. The results indicated that Black male faces captured the attention of White participants more than White male faces. Other studies of attention have found that White participants differentially attend to Black faces within 100 ms of stimulus onset (Ito & Urland, 2003). Furthermore, these attention biases appear to activate stereotypical concepts, as evidenced in the simultaneous presentation of the face and stereotype-related words facilitating categorization (Bartholow & Dickter, 2008).

Precisely how these attention biases impact later processing is not fully known, but some researchers suggest that it may account for the "own-race bias" (ORB) in face recognition (Hills, & Lewis, 2006). The ORB in face recognition is the robust effect found when White participants view a series of White and Black faces, but make more errors when remembering the Black faces at a later time period (Meissner & Brigham, 2001). Other researchers have used eye-tracking technology to support the idea that attention biases cannot account for the ORB in face recognition, but instead White participants are less sensitive to changes in Black faces (Hirose & Hancock, 2007).

A failure of White participants to detect changes in Black faces can also be found in emotion processing. For example, Hugenberg and Bodenhausen (2004) showed White participants computer generated White and Black faces whose expression changed from happy to angry or from angry to happy at precisely the same rate. White participants were faster to indicate a happy expression on a White face and an angry expression on a Black face, demonstrating that racial "biases" may exist in nonverbal communication as well.

Ingroup/Outgroup. Although plenty of findings suggest that White participants exhibit several biases when encountering a Black face, some researchers have called into question the extent to which these effects are restricted to White participants (Dickter & Bartholow, 2007; Kurzban et al., 2001). In fact many of the biases recently reviewed have been generalized to racial outgroups. For example, Dickter and Bartholow (2007) had Black and White participants complete a modified flanker task, in which an array of Black and White faces were presented. The participants were asked to identify whether the face in the center was a male or female as electro-cortical activity was being recorded. The results indicated that both Black and White participants attended to racial outgroup faces at around 200 ms. This study suggests that racial "biases" may exist when a person of any race perceives a member of *their* racial outgroup.

Further investigations into the ORB face recognition bias and the recognition of emotion biases reveals that the effects hold true when participants, regardless of race, process the face of any racial outgroup member (Weishbuch & Ambady, 2008; Brown, Bradley, & Lang, 2006). Based on these findings it appears as though many of these biases can be captured by racial ingroup versus racial outgroup processing. These findings have led to the claim that during person perception, race is privileged during categorization (Fiske et al., 1999).

Coalitions. Although there is little reason to dispute the finding that race is categorized quickly and captures the attention of perceivers, the explanation that the brain/mind treats race as a privileged category during person perception is misleading in light of an evolutionary perspective (Kurzban et al., 2001). As an alternative explanation,

Kurzban et al. (2001) suggest that race categorization is a byproduct of a cognitive mechanism designed by natural selection to detect and track coalitions, not race per se. To begin with, if race information is processed by a cognitive mechanism, discovering why that cognitive mechanism evolved is essential to understanding its underlying order. The researchers reasoned that for the majority of human evolutionary history, individuals rarely travelled more than 40 miles when establishing new residential locations (Kelly, 1995), and would rarely, if ever, encounter another human that possesses the phenotypic features that we use today to classify races. As such, a cognitive mechanism designed to process race information seems implausible (Kurzban et al., 2001). However, humans did constantly face the problem of competing with other bands and coalitions for resources (Keeley, 1996), so detecting and tracking these affiliations would have been crucial for surviving (Kurzban et al., 2001). Furthermore, it was hypothesized that a well designed coalition tracking mechanism should contain built-in assumptions making it sensitive to (1) patterns of cooperation or allegiance and (2) visual cues corresponding to these patterns (Kurzban et al., 2001).

To test the hypothesis that race categorization is a byproduct of a cognitive mechanism adapted to detect and track coalitions, Kurzban and colleagues (2001) used a memory confusion protocol, in which participants make impressions on a series of faces with comments supposedly said by each face. After some time, the participants are given a surprise memory recall task where they are asked to match each face with the corresponding comment. More within group errors, meaning the incorrect pairing of a comment to a face, suggest the encoding of that group (Taylor, Fiske, Etcoff, &

Ruderman, 1978). Initially, the researchers showed participants Black and White faces in which the comments indicated allegiance (e.g. "I've got your back."). Initially, the cues indicating cooperation did not correlate with either the White or Black faces. When structured this way, participants made more within group errors in the surprise memory recall task, both within races and within coalitions, indicating that they encoded both race and coalition. In a separate sample, participants viewed the same White and Black faces with the same comments indicating allegiance, except that those faces indicating ingroup allegiance had yellow shirts superimposed on them, and those faces indicating outgroup allegiance had grey shirts superimposed on them. With this new addition of shirt color, patterns of cooperation *and* visual cues were correlated, while simultaneously being orthogonal to race. The results of this experiment indicated that participants made more within group errors based on coalition (or shirt color) and not race, essentially suggesting that participants no longer encoded the race of each face (Kurzban et al., 2001). Taken together, this finding demonstrates that the cognitive mechanism that produces the quick and effortless categorization of race is in fact designed by natural selection to detect and track coalitions, not race per se.

More support for the coalition mechanism can be found in the face recognition literature (Bernstein, Young, & Hugenberg, 2007). Van Bavel, Packer, and Cunningham (2008) assigned participants to one of two mixed-race groups and used an arbitrary team name (i.e. Tigers or Leopards) to make group distinctions. Participants viewed faces of both their group and the opposing group and were later asked to either identify each face by group membership or by race. The functional neuro-imaging results showed that

participants had significantly more activity in the fusiform face area when viewing members of their in-group (i.e. Tigers or Leopards) than their out-group. In addition, there were no significant differences in the fusiform face area activity when participants had to categorize the faces by race (Van Bavel, Packer, & Cunningham, 2008). These results support the notion that the categorization of race leading to face recognition biases, are being processed with cognitive mechanisms designed to detect and track coalitions, not race per se.

In addition, Mondillon, Niedenthal, & Droit-Volet (2007) discovered that White participants mimicked more, and detected faster, the facial expressions of other White faces in comparison to Chinese faces. The importance of this finding lies in the repercussions that face mimicry, or lack thereof, has on social interactions. For example Chartrand and Bargh (1999) found that increased mimicry of a participant by an experimenter, led the participant to rate the experimenter as being more likeable and reporting a smoother interaction with them. Similarly, van Baaren, Holland, and Kawakami (2004) discovered that participants who were mimicked more by a confederate exhibited more prosocial behavior, in that they were more willing to help and more likely to donate money to a charity. These findings suggest that nonverbal behavior (i.e. face mimicry) increases likeability and cooperation between two or more people, and that there is a *lack* of face mimicry for outgroup members. Theoretically these findings make sense in light of the function of the coalition mechanism. If the detecting and tracking of coalitions over evolutionary time were important when competing for resources, then being less cooperative with a competing coalition would be necessary for

successful outcome.

Direct evidence of a cooperation "bias" based on coalitions can be found in the minimalist group paradigm created by Tajfel (1970). In this paradigm participants were randomly assigned to an arbitrary group and told to allocate resources to one group or the other. Also, participants were told that they would not personally receive any of the resources, but that they would simply be awarded to the team as a whole. In fact, participants allocated more resources to their own group, even when the group was arbitrary, novel, and they knew no one within the group (Tajfel, 1970).

In sum, race categorization appears to be a special case of coalition detection, in that the cognitive mechanisms that have evolved to detect and track coalitions are used to process race information. This is likely the case in cultures and societies where (1) patterns of cooperation (i.e. segregation) and (2) visual cues corresponding to these patterns (i.e. skin color) are present. However, regardless of whether the categorization is along the dimension of race, ethnicity, or shirt color, reliable biases in face mimicry, emotion recognition, memory, and attention reliably emerge (e.g., Dickter & Bartholow, 2007; Mondillon et al., 2007; Kurzban et al., 2001). Each of these biases result from a cognitive mechanism that detects and tracks coalitions, suggesting that a more complete understanding of how this mechanism functions requires understanding its relationship to additional cognitive mechanisms.

In taking an evolutionary approach, the function of a cognitive mechanism is central, however, not every mechanism functions to directly produce a behavior. Instead many of these cognitive mechanisms store information as parameters to regulate

additional cognitive mechanisms that *do* produce a behavioral output (Tooby, Cosmides, Sell, Lieberman, & Sznycer, 2008). An example of this can be found in the sociometer theory of self-esteem (Kirkpatrick & Ellis, 2001). As such, the cognitive mechanism that detects and tracks coalition affiliations should either produce behavioral outputs, or regulate other mechanisms that do. Considering that behaviors are carried out through the rest of the body, the next section will explore the intricate relationship between the brain/mind and the body.

Embodiment

Although some cognitive mechanisms store parameters or summary magnitudes, they do so to integrate this information into the regulation of behavior (Tooby, Cosmides, Sell, Lieberman, & Sznycer, 2008), in an attempt to move the body through the world in adaptive ways *on average* (Wilson, 2002; Grafton, Fadiga, Arbib, & Rizzolatti, 1997; Goodale & Milner, 1992; Tooby & Cosmides, 1992, 1995). To be clear, "adaptive" in a biological sense is anything that enhances the survival and reproduction of an individual or the individual's genetic relatives (Tooby & Cosmides, 1990). Even though enhanced reproduction is the *ultimate* goal in natural selection, it typically cannot be achieved without meeting an array of *proximate* goals in the process (Tooby & Cosmides, 1992). To accomplish many of these goals, it is likely that an organism must move through its environment (i.e. foraging, avoiding predators, finding mates), but without computational machinery, the range of possible movements approaches infinity (Tooby & Cosmides, 1992). As a result, organisms without a brain typically do not move. For example, plants do not move, but instead attract insects that can move to successfully reproduce. One

plant that does move, *Dionaea muscipula* or venus flytrap, utilizes action potentials to distinguish between an insect and a raindrop when deciding on closing its trap (Hodick & Sievers, 1987). In addition, the tunicate, or sea squirt, begins its life cycle with a cerebral ganglion allowing it to move through the ocean in search of a location to permanently attach itself. After it is attached, the tunicate digests its cerebral ganglion because it no longer needs to move (Towle & Towle, 1989). So, from a functional perspective, it makes little sense to study the brain/mind in isolation *from the very body it attempts to control.*

Embodied cognition is a view acknowledging that the brain/mind processes information from the body as well as the environment (e.g., Chambon, 2009). An example of embodied cognition is the feeling or sensation of hunger. When the stomach becomes empty the peptide ghrelin, which exists in high concentrations in the stomach, is released into the bloodstream. In turn, ghrelin stimulates the hypothalamus which sends signals to the anterior pituitary to inhibit the release of thyroid stimulating hormone (TSH) and adrenocorticotropic hormone (ACTH), two hormones that generate the feeling of being full, thus creating a state of hunger (Bear, Connors, & Paradiso, 2007) which likely activates cognitive mechanisms implicated in foraging behaviors (Bear, Connors, & Paradiso, 2007; Tooby, Cosmides, Sell, Lieberman, & Sznycer, 2008). Examples of embodied cognition go beyond such internal states as hunger, and are being discovered in areas such as perception (Proffitt, 2006), language (Glenberg, Sato, Cattaneo, Riggio, Palumbo, & Buccino, 2008), emotion (Niedenthal, Winkielman, Mondillon, & Vermeulen, 2009), attitude formation (Cacioppo, Priester, Bernston, 1993) and empathy (Decety & Jackson, 2006).

Perception. Proffitt, Stefanucci, Banton, and Epstein (2003) explored the effect that metabolic cost has on the perception of distances. Participants made estimates of distances to a variety of targets, with half of the participants wearing a heavy backpack, and the other half without a backpack. The participants that wore the heavy backpack estimated the distances to be significantly farther away than those without the backpack. Similar findings were found in the perception of slopes (Bhalla & Proffitt, 1999). In both studies, the effect is described in terms of the "economy of action" (Proffitt, 2006) which suggests that the brain/mind receives inputs from the body regarding its current available energy, which regulates some of the computations being made by the cognitive mechanisms involved in perceiving spatial layout, in an attempt to guide behavior in an adaptive way.

Attitudes. Similar embodied effects have been discovered in the formation of attitudes. Cacioppo, Priester, and Berntson (1993) had participants judge novel Chinese ideographs while flexing or extending their upper arm. By flexing the upper arm, a motor movement similar to pulling in towards the body is achieved, and extending the arm produces a movement similar to pushing away. As a result, participants rated the Chinese ideographs more favorably when they were simultaneously presented during arm flexion rather than arm extension. Similarly, Wells and Petty (1980) presented identical persuasive arguments to two groups of participants. One group of participants was instructed to move their head vertically while listening, and the other group was instructed to move their head horizontally. As expected, the participants who moved their heads vertically while listening to the message were more persuaded by the arguments

than those engaged in the horizontal head movements. Similar findings were discovered with elderly stereotype primes and rate of walking, such that participants subliminally primed with words related to older people walked more slowly as a result (Bargh, Chen, & Burrows, 1996). In each of these studies, the authors attempted to explain their results in terms of associations. However, a contemporary embodied and evolutionary approach suggests that these domain-specific cognitive mechanisms are sensitive to inputs from both the body and the environment, producing outputs (i.e., attitudes) reflecting the product of the inputs.

Emotions. Closely related to the previous discussion of the embodiment of attitudes, is the finding that emotions are also affected by bodily states. For example, Strack, Martin, & Stepper (1988) asked participants to hold a pen in their mouth, inadvertently contracting or relaxing the zygomaticus muscle, as they read and rated cartoons. Participants who were contracting their zygomaticus (i.e., smiling) rated the cartoons significantly more favorable. A wealth of empirical findings has also demonstrated that humans quickly and non-consciously mimic the facial expressions of others, in degrees corresponding to the perceived expression (e.g., Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Francois, 2005). Furthermore, mimicking facial expressions has been shown to facilitate the categorization and detection of emotions (Niedentahl et al., 2005), as well as promote likeability (Chartrand & Bargh, 1999).

Chartrand and Bargh (1999) have demonstrated that humans mimic or imitate more than just facial expressions of others, but also postures and mannerisms, naming it the "Chameleon Effect". These findings suggest that many facets of social cognition may be

grounded in action, presumably relying on the somatosensory and motor cortex. Not surprisingly, clinical patients with damage to their somatosensory cortex show marked impairments in identifying emotional expressions (Adolphs, Damasio, Tranel, Cooper, & Damasio, 2000). Enticott, Johnston, Herring, Hoy, and Fitzgerald (2008) used transcranial magnetic stimulation (TMS) over specific areas of the motor cortex while participants viewed static images of facial expressions and patterns, demonstrating that activation in the motor cortex significantly correlated with face processing and mimicking, but had no relationship with the ability to recognize patterns. These findings, along with a myriad of others suggest a special case of embodiment called "embodied simulation" (Gallese, 2005).

Mirror Neurons. In 1992, di Pellegrino, Fadiga, Fogassi, Gallese, and Rizzolatti discovered a subset of motor neurons with unique properties. The researchers were taking single-cell recordings from the macaque motor cortex, in an attempt to map its functional organization. Surprisingly, a subset of motor neurons not only fired when the macaque performed an action, but also when the macaque observed the same action being performed by the experimenter. Furthermore, di Pellegrino et al. (1992) discovered that these neurons only discharged when observing goal directed actions, and they did not exhibit firing patterns consistent with a motor preparation, or "priming", hypothesis (Rizzolatti, Fadiga, Gallese, & Fogassi, 1996).

Recently, Uddin, Iacoboni, Lange, and Keenan (2007) reviewed the mirror neuron literature, explaining that in the macaque, mirror neurons are sensitive to the precise grip being used in the goal-directed action, and discharge when the macaque receives auditory

input related to the action (i.e. seeing a peanut being cracked and hearing a peanut being cracked). In humans, single cell recordings of mirror neurons have not been obtained, but noninvasive neurophysiological evidence suggests that there exist neurons with similar, if not identical, functional properties as mirror neurons (Uddin et al., 2007). Essentially, "embodied simulation" is thought to be exemplified by mirror neurons, in that a perceived action is encoded by many of the same neurons that would be required to perform that action. What follows is a review of the EEG evidence for embodied simulation in humans, and how it relates to many of the nonverbal biases found in coalition processing.

Mu Rhythm. Electroencephalographic (EEG) recordings are thought to be a product of the electrical activity at the post-synaptic receptors in large populations of neurons. Within the EEG recordings, researchers may apply a variety of techniques to isolate the physiological activity thought to be associated with a particular cognitive process. One of the techniques used analyzes frequency oscillations in the brain. For example, the stages of sleep can be characterized by distinct frequency bands. In addition to the stages of sleep, recent research has revealed an interesting frequency band over the sensorimotor cortex that has similar functional properties as mirror neurons (Pineda, 2005).

The mu rhythm is typically described as an 8-12 Hz frequency oscillation occurring over the sensorimotor cortex in nearly all healthy adults (Pineda, 2005). When the mu rhythm was originally discovered it was dismissed as an epiphenomenon, but as statistical and EEG techniques have improved it has received much more attention

(Pineda, 2005). In short the mu rhythm is thought to reflect the synchronized firing of motor neurons in an "idling" state (Pfurtscheller & Neuper, 1994), but the interesting characteristic of the mu rhythm is that it becomes desynchronized when an individual makes a motor movement *and* when an individual perceives a motor movement (Pineda, 2005). It is thought that the desynchronization occurs due to a subset of neurons in the motor cortex firing at a frequency outside of the 8-12 Hz range. Simply put, more desynchronization of the mu rhythm suggests more embodied simulation. With properties nearly identical to mirror neurons, many researchers suggest that the mu rhythm reflects mirror neuron activity, and have found empirical support implicating it in many social cognitive processes (Ulloa, & Pineda, 2007; Yang, Decety, Lee, Chen, & Cheng, 2009).

The desynchronization of the mu rhythm has been induced by viewing point-light biological motion versus scrambled point-light motion (Ulloa & Pineda, 2007), by performing and observing precision grasps (Muthukumaraswamy & Johnson, 2004), and by viewing images of others in pain (Yang, et al., 2009). Evidence with subdural electrodes has revealed that mu rhythm desynchronization corresponds to specific somatosensory regions within the cortex (i.e. face areas, hand areas) (Arroyo, Lesser, Gordon, Uematsu, Jackson, & Webber, 1993). In addition to the support for the mirror neuron hypothesis of the mu rhythm, other empirical investigations have revealed the mu rhythms involvement in a variety of social cognitive processes.

McFarland, Miner, Vaughan, and Wolpaw (2000) asked participants to perform and imagine performing bilateral hand movements. Both performing these movements and imagining performing them significantly desynchronized the mu rhythm. The authors

report these findings in light of the potential usefulness in brain-computer interfaces, but these results have theoretical implications as well. For example, Yang et al. (2009) recorded the mu rhythm of individuals as they viewed images of hands in potentially painful and non-painful situations (e.g., scissor blades near one's fingers). As hypothesized, there was significantly more mu desynchronization while participants viewed the painful images than non-painful images. Furthermore, Yang and colleagues (2009) discovered that female participants had significantly more mu desynchronization than male participants which is compatible with the gender differences often found in empathic processing. These findings begin to suggest the role of the mu rhythm in empathy, yet direct evidence for its role in basic social interactions exists (Oberman, Pineda, & Ramachandran, 2007).

Oberman et al. (2007) varied levels of social interaction, in that participants viewed video clips of three individuals either (1) tossing a ball in the air to themselves, (2) tossing a ball to each other, and (3) tossing a ball to each other *and* towards the camera as if to include the participant. The researchers found that as the level of social interaction increased, the participants' mu rhythm became more desynchronized. In addition, Pineda and Hecht (2009) found that mu rhythm desynchronization positively correlated with the accuracy on an emotion matching task and a person-object interaction matching task, both of which tested subcomponents of the theory of mind. Based on these results, the authors concluded that the mu rhythm likely reflects the neural underpinnings involved in linking perception and action, but *not* beliefs and intentions.

Finally, researchers have long marked the social impairments in those with Autism

Spectrum Disorder (ASD), motivating studies implicating mirror neurons and the mu rhythm in particular. Oberman, Hubbard, McCleery, Altschuler, Ramachandran, and Pineda (2005) had healthy adults and age and IQ matched adults with ASD watch a video of a hand performing a series of gestures. The participants were asked to watch the videos and then perform those actions later as EEG was being recorded. The researcher discovered that although there were no differences in the mu rhythm desynchronization between healthy and ASD participants during the performance trials, there was significantly more mu rhythm desynchronization for the healthy adults while perceiving others' motor movements compared to those with ASD. Bernier, Dawson, Webb, and Murias (2007) found nearly the same results; however, they did discover that their sample of ASD participants scored significantly lower on a behavioral imitation task.

These investigations into the mu rhythm have demonstrated its importance in the successful imitation and mimicry of other individuals. Essentially, the mu rhythm is a biological reflection of the neuro-computations performed when an individual perceives an action with the intentions of producing a behavior congruent or compatible to it (Pineda, 2005).

The Current Research

Imitation and face mimicry have been shown to be crucial antecedents to the recognition of emotions (Adolphs, Damasio, Tranel, Cooper, & Damasio, 2000; Niedenthal et al., 2005; Enticott, Johnston, Herring, Hoy, and Fitzgerald, 2008) as well as facilitate likeability and cooperation between individuals (Chartrand & Bargh, 1999). Likewise, a number of studies have revealed that there exists emotion recognition and

face mimicry biases during the processing of race or coalition information, such that there tends to be less face mimicry, a lack of face recognition, and less cooperation when interacting with members of an outgroup (Weishbuch & Ambady, 2008; Brown, Bradley, & Lang, 2006; Hugenberg & Bodenhausen, 2004; Mondillon et al., 2007). This research seems to suggest that the coalition mechanism store parameters regarding an individual and regulates nonverbal behavior, such as face mimicry and imitation. This regulatory process is being discussed at the functional level of analysis, but as mentioned previously, these computations are physically instantiated in the neural tissue of the brain. The discovery of mirror neurons and subsequently the mu rhythm, seems to suggest the biological reflection of face mimicry and imitation (Pineda, 2005). If this is true, the mu rhythm should reflect the neuro-computations performed by the coalition mechanism to regulate an array of nonverbal behaviors. As such, the first study will test the hypothesis that the neuro-computations performed to process race information will store important parameters regarding a perceived individual, such that these parameters will regulate important nonverbal "biases" that are biologically reflected in the desynchronization of the mu rhythm. The second study will test a similar hypothesis, but will assign participants to a novel group to test the prediction that the regulation of the nonverbal behaviors reflected in the mu rhythm, is sensitive to rapidly shifting coalition affiliations.

Study 1

The first study tested the hypothesis that the neuro-computations performed to process race information would regulate the desynchronization of the mu rhythm, such

that perceiving goal-directed actions performed by racial ingroups would elicit significantly more desynchronization than racial outgroups. To test this, participants viewed videos depicting Black and White male hands performing goal-directed actions while the mu rhythm was recorded during the observation of the actions.

Method

Participants

Twenty Introduction to Psychology students (13 Females, 7 males), with a mean age of 18.7 years, participated for course credit. All participants self-identified as White with no history of neurological illness. This study was reviewed and approved by the Institutional Review Board at the College of William & Mary.

Materials

Three self-report questionnaires measured empathy, personal familiarity with and attitudes towards Blacks. First, the Interpersonal Reactivity Index (IRI) is 28-item measure of dispositional empathy containing four 5-point likert subscales of perspective taking (PT), empathic concern (EC), personal distress (PD), and a fantasy scale (FS) (Davis, 1983; see Appendix A).

Next, to assess participants' familiarity with and contact with Blacks, a 14-item familiarity questionnaire was compiled from a familiarity measure (Greenwald, McGhee, & Schwartz, 1998), a social contact scale (Walker, Silvert, Hewstone, & Nobre, 2008), and an individuating experience scale (Walker et al., 2008). The familiarity measure is an unobtrusive measure used to record the average number of Black friends each participant has. The social contact scale measures general contact with Blacks. Finally, the

individuating experience scale measures interpersonal or close contact with Blacks (see Appendix B).

Finally, the Attitudes Towards Blacks (ATB; Brigham, 1993) assessed racial prejudice. The ATB is a 20-item 7-point Likert-type scale measuring explicit racial prejudice (Brigham, 1993; see Appendix C).

Stimuli

The stimuli consisted of 40 second (s) video clips depicting either a Black or White male right hand reaching for objects on a table. The actors recorded for the videos were volunteer college students recruited by a research assistant. None of the actors recorded had tattoos, markings, or jewelry on the arm used in the goal-directed actions. A total of four Black males, four White males, four Black females, and four White females were recruited and their hands recorded, however only three Black male and three White male hands were used in Study 1. Additionally, there were control clips that showed, for the same 40 s period only the objects on a table and only visual white noise. The condition with only the objects was used to control for any low level visual properties of the objects, and to provide a baseline measure of mu rhythm power for each participant. Since the mu rhythm frequency range overlaps with that of occipital alpha (8-12 Hz), the visual white noise helped control for this, and unlike the objects only condition, the white noise contained movement (Oberman et al., 2007). All videos were recorded in the same room with the same camera using QuickTime Movie to control for low level visual properties. Each video was cropped to achieve the dimensions of 960 X 540 and a length of 40 s. In addition, a separate sample of seven participants were asked to identify the

race of the hand in each video. All videos were correctly identified 98% of the time. All videos were 40 s in length and were shown twice to the participants, with the exception of the objects only and visual white noise being shown six times each. This length ensured that the same number of seconds of data would be analyzed as had been done previously (Oberman et al., 2007).

The objects used in the videos consisted of a black and white cup, a yellow foam ball, and a white board eraser. All objects were positioned in the same location on the table for each video. Furthermore, these same objects were recorded, without hand movements, as a baseline measure containing nearly identical visual properties with the exception of the Black of White hand. Each hand that was recorded grasped the objects as if they were going to use each object in an attempt to simulate a goal-directed action. The hands grasped and removed each object from the visual field in two different orders, then placed the objects back down in the visual field in the same locations in which they started. Therefore, the *only* difference between the Black and White hand videos was the race of the hand performing the actions.

Procedure

Participants completed the study individually in an electrically shielded EEG recording booth. When they arrived at the study, they read and signed the informed consent. Next, a White male researcher attached and tested the electrodes. EEG data were collected while participants viewed four different video conditions: (1) Visual White Noise (mean luminance 3.7 cd/m^2), (2) Black male right hand grasping the objects, (3) White male right hand grasping the objects, and (4) the objects on a table. In the white

noise, Black hand, and White hand conditions, each video would pause for 1.5 s randomly 1-3 times during the 40 s period. To ensure that the participants attended to the videos, they were told to count the number of times each video paused and to record this number *after* the video ended. After each video, participants were allowed time to record their responses and would press a key on a joystick to continue to the next video. Prior to each video was a 5 s baseline period with a grey screen. Participants were shown six videos representing each condition in random order. The Black and White hand videos consisted of three different Black or White hands respectively, but each hand was shown twice for a total of six videos.

After the participants finished viewing the videos, they were asked to record what they thought was the purpose of the experiment. Next, the experimenter came in to the EEG booth with the four objects that were previously shown in the videos (i.e., cup, ball, and eraser). The participants proceeded to grasp each object continuously for 100 s, in a manner similar to each video, but were told that they did not have to imitate the previously shown actions. This participant grasping procedure was initially intended to serve as an additional baseline, in that it should demonstrate the full desynchronization of the mu rhythm. However, this condition was not analyzed considering that the white noise and objects only conditions provided a sufficient baseline measure. Finally, the IRI, familiarity, and ATB scales were administered on paper, one at a time respectively, and then the participants were debriefed.

Electroencephalography

Electrophysiological data were recorded continuously at 2000 samples per second

using a DBPA-1 Sensorium bio-amplifier (Sensorium Inc., Charlotte, VT) with an analog high-pass filter of 0.01 Hz and a low-pass filter of 500 Hz (four-pole Bessel). Recordings were made using an extended 10-20 cap system with 72 Ag-AgCl sintered electrodes while participants were seated in an electrically shielded booth. EEG recordings were made using a forehead ground electrode and a reference at the tip of the nose. Vertical and horizontal eye movement was recorded from peri-occular electrodes placed on the superior and inferior orbits (centered with the pupil) and from electrodes placed at the lateral canthi respectively. All impedances were adjusted to within 0-20 kilohms at the start of the recording session.

EEG data were undersampled at 500 Hz and analyzed off-line using EMSE (Source Signal Imaging, San Diego, CA). Individual channels were then analyzed in one-second sweeps over the entire recording epoch. Channels containing extreme values (+/- 300 μV) in more than 40% of the sweeps were replaced by interpolation (spherical spline). Additionally, sweeps in which more than 20 (28%) of the channels were contaminated by such artifact were removed from the analysis. The data were corrected for ocular artifact using independent components analysis (Jung, Makeig, Humphries, Lee, McKeown, Sejnowki, 2000), low-pass filtered at 20 Hz.

EEG data were collected for approximately 240 s per condition, however, since the 8-12 Hz frequency range of the μ rhythm overlaps with the occipital alpha band, the first and last 10 s of each video were excluded from analysis to eliminate possible attentional transients due to initiation and termination of the stimulus (Oberman et al., 2007). This resulted in a total of 120 s of EEG data to be analyzed per condition. In addition, data

were recorded over the entire scalp, but since the μ rhythm occurs over the sensorimotor cortex only data from electrodes C3, Cz, and C4 were analyzed.

Data were segmented offline into epochs of 2 s beginning at the start of each 20 s segment within each video. Fast Fourier transformations were performed on each 2 s epoch to obtain the power of each frequency. A hanning cosine window was used to control for artifacts resulting from data splicing. Then, the 2 s epoch power values in the 8-12 Hz frequency range were averaged across videos within each condition. The mu desynchronization was calculated by taking the ratio of the power values in the 8-12 Hz frequency range for each condition relative to the power values in the 8-12 Hz frequency range for the objects only condition. Natural logarithmic transformations were performed on each ratio score because of the inherent non-normality of ratio data (Oberman et al., 2007). This resulted in a total of three log ratio scores for each participant, representing mu power relative to baseline for the Black hand, White hand, and white noise conditions.

Results

Behavioral Performance

One participant was excluded due to being left-handed, and one more participant was excluded due to data processing issues. The remaining eighteen participants all self-identified as being White (12 Females, 6 males), with a mean age of 18.74 years, were right-handed, and reported having no history of a neurological illness. The average accuracy score on the continuous performance task was 97% (*SD*=0.04), therefore, potential differences in mu desynchronization were most likely not due to differences in

attention.

Mu Desynchronization

Prior to running the analysis on the log of the ratio data, the cleaned EEG data from each participant were segmented such that the onset and offset of each video was spliced together. An independent components analysis (ICA) revealed a signal with an increase in 8-12 Hz activity that was distributed on the scalp over the sensorimotor cortex. This suggested that a subcomponent within the entire EEG signal was similar to the mu rhythm.

The log of the ratio scores indicative of mu desynchronization for each condition were subjected to a repeated-measures Analysis of Variance (ANOVA) with three levels corresponding to each condition (White hand, Black hand, Visual white noise). Results indicated a significant effect of condition, $F(2, 34) = 3.63$, $p < 0.05$, $\eta^2_p = 0.19$ (see Figure 1; Greenhouse-Geisser degrees of freedom reported). To confirm that goal-directed actions elicited significantly more mu desynchronization than visual white noise, a planned contrast compared the weighted average of the Black and White hand conditions (M=-0.14, SE=0.04) with the visual white noise condition (M=-0.05, SE=0.06), revealing significantly more mu desynchronization for goal-directed actions, $t(17)$=2.26, p=0.038, r^2=0.45. A planned contrast testing the *a priori* hypothesis that White hands (M=-0.15, SE=0.05) would elicit more mu desynchronization than Black hands (M=-0.14, SE=0.04) revealed no significant difference, $t(17)$=-0.39, p=0.70.

Individual Differences

Means and standard deviations of each subscale used are reported in Table 1. To

examine potential relationships between mu desynchronization and empathy, familiarity, or racial prejudice, a "mu bias" score was correlated with each questionnaire or subscales. The "mu bias" score for each participant was computed by subtracting the White hand condition from the Black hand condition. Therefore, larger positive scores indicate more mu desynchronization for the White hand condition relative to the Black hand condition (M=0.012, SD=0.13). Eight females (66%) and three males (43%) demonstrated more mu desynchronization for the White relative to Black condition. The only relationship that emerged was a positive correlation between mu bias and the IRI fantasy subscale, $r(16)$=0.54, p=0.02 (see Table 2).

Discussion

This study examined whether White participants, when processing race information, would show less mu rhythm desynchronization to racial outgroup versus racial ingroup members, presumably indicating less mirror neuron activity or embodied simulation. The results indicated that there was no significant difference when perceiving White or Black hands. There was, however, significant mu desynchronization for both the White and Black hands in comparison to the visual white noise indicating that the neuro-computations being performed while participants viewed goal-directed actions did, at least in part, involve the sensori-motor cortex.

The fact that there were no significant differences between White and Black hands in the desynchronization of the mu rhythm suggests that the cognitive mechanisms designed to detect and track coalitions, in this case race, do not regulate the mu rhythm. With the previous investigations of the mu rhythm demonstrating its sensitivity to

computations related to imitation (Oberman et al., 2005), empathy (Yang et al., 2009), and theory of mind (Pineda & Hecht, 2009) it is puzzling *not* to discover significant differences in mu desynchronization between racial ingroups and outgroups. Especially considering the wealth of literature finding reliable race or coalition biases in face recognition (Weishbuch & Ambady, 2008; Brown et al., 2006), and emotion recognition (Mondillon et al., 2007; Hugenberg & Bodenhausen, 2004), each of which have been shown to require imitation and mimicry (Mondillon et al., 2007; Niedenthal et al., 2005).

First, it should be mentioned that data from only 18 participants were collected. Although other investigations of the mu rhythm reported sample sizes of 23 (Pineda & Hecht, 2008), 20 (Oberman et al., 2006), and 16 (Muthukumaraswamy & Johnson, 2004), it may be that the particular effect tested in this study requires a larger sample, due to potential moderating variables.

One possibility is that, in this particular sample, information regarding one's race did not serve as visual cues corresponding to coalitions. However, considering that during the pilot testing of each video, a separate sample was able to correctly identify the race of each hand, and that a number of studies have found that people quickly and effortlessly categorize race based on visually prominent cues (Fiske, et al., 1999), it seems logical to suggest that participants likely implicitly categorized race. However, this study was not capable of ensuring that participants were implicitly categorizing race.

If participants were in fact categorizing race, it may be that this distinction was not salient enough to elicit differences in the mu rhythm. For example, if the mu rhythm reflects processes related to imitation (Oberman et al., 2005), and imitation improves

likeability and cooperation (Chartrand & Bargh, 1999), it may be that the computational machinery that detects and tracks coalitions will only regulate the mu rhythm when the context involves cooperation and competition.

Finally, results revealed a significant relationship between the differential mu desynchronization between the White and Black hand conditions and the fantasy subscale in the IRI questionnaire. There were no a priori hypotheses regarding this specific relationship, however, previous research has demonstrated an opposing relationship between mu desynchronization and empathy, specifically the IRI questionnaire (Yang, et al., 2009), making this relationship all the more puzzling.

Before addressing larger issues and limitations concerning the functioning of the mu rhythm, the limitations previously mentioned will be addressed in the second study; the original hypothesis will be tested.

Study 2

The original aim of the second study was to test the hypothesis that the cognitive mechanism designed to detect and track coalitions will regulate the mu rhythm, even as coalitions rapidly change. However, since the first study did not support the regulation of the mu rhythm by the coalition neuro-computation machinery, the second study served to address the limitations of the first study. As such, the two limitations that were addressed were whether the visual cues indicative of the coalitions were salient, and whether cooperation and competition were necessary contextual factors. Thus, this study was nearly identical to the first study, except that participants were randomly assigned to a novel group. A minimal group paradigm (Tajfel, 1970) was used to create a new

coalition, which was represented by a certain color on a wrist band. After being told that they were a member of one of the novel coalitions, participants viewed the same goal-directed actions as in Study 1, the only difference being that these hands were wearing a wrist band indicating which coalition they belonged to. Finally, participants were told that they were competing against the opposing team for a monetary reward, in order to increase the salience of the ingroup and outgroup coalitions.

Participants

Thirty-two Introduction to Psychology students (9 Females, 23 Males) with a mean age of 19.1 years participated for course credit. All participants self-identified as being White and having no history of neurological illness. This study was reviewed and approved by the Institutional Review Board at the College of William & Mary.

Materials and Stimuli

The IRI, familiarity, and ATB questionnaires were identical to those used in Study 1. Additionally, the same four objects used in Study 1, (i.e., Black cup, White cup, yellow foam ball, and dry-erase eraser) were again used to create new videos and were grasped by the participants. Videos nearly identical to the videos in the first study were used. The only difference between the videos in Study 2 and those in Study 1 was that the actors performed the goal-directed actions wearing a red wrist band, and then with a blue wrist band. All videos were recorded with the same camera using QuickTime Movies and cropped to achieve dimensions of 960 X 540 and a 40 s length. These videos were also pilot-tested for race and wrist band color identification and clarity. Additional materials

were used in the coalition and minimalist group manipulation and will be discussed in that section.

Manipulation

The procedure of the second study was similar to the first study with the addition of the coalition and minimalist group manipulation. First, participants entered the electrically shielded EEG both, read and signed an informed consent. Next, participants were told that they would take part in a "Dot Estimation Task" to determine their perceptual bias. Instructions were:

> Perceptual estimation has been linked to an ability to detect subtle changes in motion perception. In this task you will view a series of slides depicting an array of dots. Each slide will be presented for 1.5 seconds and you will have to estimate how many dots were displayed after each slide. You will not be able to precisely count the number of dots, so please do your best to estimate the number. After each slide you will be given as much time as you need to record your answer. When you are ready to view the next slide, press the down arrow. After you have finished estimating all ten slides please wait for more instructions from the experimenter.

For this task, participants viewed ten slides with a random display of approximately 30-80 dots, one at a time for 1.5 seconds. After each slide the participants recorded the number of dots they perceived on the slide. At the end of the "Dot Estimation Task", the experimenter took the answer sheet used by the participant, left the room for a few minutes as if to record their answers, and came back with a "Results" sheet telling the participant whether they were a "Perceptual Over Estimator" or "Perceptual Under

Estimator" which was counterbalanced between participants. The "Results" sheet was bogus feedback designed to provide a legitimate assignment to one of the two groups (i.e. red or blue team). This manipulation was derived from Tajfel's (1970) minimalist group paradigm.

It was explained to the participant that this has been linked to motion perception, and that is precisely what the study was testing. Furthermore, the participant was provided either a red or blue wrist band (counterbalanced between participants *and* perceptual bias group). Then the participants were told that they would view a series of videos in which the videos would randomly pause for 1.5 s, and their task was to count and record the number of pauses per video. Participants were informed that their performance on this task was important because their accuracy score would be averaged with their team's average accuracy (their team being their wrist band color), and the team with the highest average accuracy would determine how a monetary reward would be allocated between teams.

Video Conditions

As mentioned earlier, these videos were nearly identical to the first study, with the exception that half of the Black hands wore a red wrist band and the other half wore a blue wrist band; the same was true for the White hands. In other words, the wrist bands were orthogonal to race, resembling previous manipulations of coalition (Kurzban et al., 2001). There were an equal number of Black hand and White hand videos for each the red and blue wrist band teams, leading to total of four videos each shown twice per each of the four conditions. Thus, the four experimental conditions were as follows: (1) Black

with a red wrist band, (2) Black with a blue wrist band, (3) White with a red wrist band, and (4) White with a blue wrist band. However, the hypothesis was concerned with coalitions based on wrist bands, and since wrist bands were counterbalanced between participants, these conditions had to be reorganized in accordance with the participant's wrist band color. As such four new conditions were formed: (1) Black ingroup wrist band, (2) Black outgroup wrist band, (3) White ingroup wrist band, and (4) White outgroup wrist band. Additionally, the two control conditions included trials involving the visual white noise and the object only conditions, which were simply averaged over trials for each participant for the analyses below. After the objects only condition was divided out of each condition, five conditions remained.

Resource Allocation

After the participants watched each video, they were asked to provide their contact information, so the experimenter could contact them regarding which team achieved the highest accuracy rate. Next, the participants were asked to allocate a $200 prize between their own team and the opposing team, based on the wrist band color. This is identical to the minimalist group paradigm created by Tajfel (1970), and was used to determine a measurement of coalition resource allocation.

After the resource allocation task, participants were asked to record what they thought the experiment was measuring, and then completed each of the three questionnaires. Finally, the participants were debriefed and dismissed.

Electroencephalography

The EEG data were recorded while the participants viewed each video. The entire

data collection, processing, and cleaning were identical to the first study. In addition, the data were segmented into 2 s epochs and Fast Fourier transforms were performed over each of these. Again, a ratio was calculated between each condition and the objects only condition, then a natural logarithmic transform was performed to correct for non-normality.

Results

Behavioral Performance

One male participant was excluded due to a suspected neurological impairment. Another male participant was excluded due to being left-handed, and one male participant was excluded due to data processing issues. The remaining twenty-nine participants all self-identified as being White (9 Females, 20 males), with a mean age of 19.13 years, were right-handed, and reported having no history of a neurological illness. The average accuracy score on the continuous performance task was 90% (*SD*=0.14), therefore, difference in mu desynchronization were most likely not due to differences in attention.

Mu Desynchronization

The log of the ratio scores indicative of mu desynchronization for each condition were subjected to a repeated-measures ANOVA with five levels corresponding to each condition. A Greenhouse-Geisser correction revealed a significant effect of condition, $F(4, 112) = 2.99, p < 0.05, \eta^2_p = 0.10$ (see Figure 3). Next, a 2(Race) X 2(Wrist Band Group) repeated-measures ANOVA was conducted, revealing no significant main effects or interaction. This test was conducted to primarily test the interaction, since the planned

contrasts tested the main effects (see below).

To confirm that goal-directed actions elicited significantly more mu desynchronization than visual white noise, a planned contrast compared the weighted average of the Black ingroup, Black outgroup, White ingroup, and White outgroup hand conditions (M=-0.17, SE=0.04) with the visual white noise condition (M=-0.05, SE=0.05), revealing significantly more mu desynchronization for goal-directed actions, $t(28)$=-2.24, p=0.033, r^2=0.05. A planned contrast testing the *a priori* hypothesis that ingroup hands (M=-0.19, SE=0.04) would elicit more mu desynchronization than outgroup hands (M=-0.15, SE=0.04) revealed no significant difference, $t(28)$=-1.23, p=0.23. To rule out the hypothesis that White hands (M=-0.17, SE=0.04) would elicit more mu desynchronization than Black hands (M=-0.16, SE=0.04), a final planned contrast averaging over wrist band group revealed no significant difference, $t(28)$=0.29, p=0.77.

Individual Differences

All means and standard deviations for each subscale are reported in Table 3. To examine any relationship between empathy, familiarity, or racial prejudice, a "mu group bias" score was correlated with each questionnaire or subscales. The "mu group bias" score for each participant was computed by subtracting the ingroup hand conditions from the outgroup hand conditions. Therefore, larger scores indicate more mu desynchronization for the ingroup hand conditions relative to the outgroup hand conditions (M=101, SD=87.4). Four females (44%) and ten males (50%) showed more mu desynchronization in the ingroup relative to outgroup condition. In addition, a

resource allocation bias score was computed for each participant by subtracting the amount of money they allocated to the opposing team from the amount they allocated to their own team (M=101, SD=87.4). Therefore larger scores were indicative of a larger resource allocation bias. Five females (56%) and thirteen males (65%) allocated more money to their own group than the opposing group.

First, a significant negative correlation was found between resource allocation bias and the empathic concern subscale on the IRI, $r(27)$=-0.37, p=0.046 suggesting that more empathy was associated with less bias in resource allocation. Next, the ATB positively correlated with the mu group bias $r(27)$=0.43, p=0.02 and negatively correlated with the allocation bias $r(27)$=-0.52, p=0.004 indicating that lower self-reported prejudice was associated with more mu desynchronization differences between groups and less bias in resource allocation, respectively. Lastly, the ATB positively correlated with the familiarity subscale of interpersonal experience $r(27)$=0.41, p=0.03, and the IRI subscales of empathic concern $r(27)$=0.60, p=0.001, fantasy score $r(27)$=0.52, p=0.004, and perspective taking $r(27)$=0.44, p=0.02 suggesting that lower self-reported prejudice was associated with higher levels of interpersonal reactivity (see Table 4).

Discussion

Study 2 was initially conducted to test the hypothesis that any regulation of the mu rhythm by the coalition detecting and tracking mechanisms was flexible during the establishment of novel coalitions. The results failed to support this hypothesis. Given that the coalition mechanism did not regulate the mu rhythm when coalitions were based on race in Study 1, it is not surprising that coalitions based on another visually prominent

feature would be any different.

Based on Study 1, the second study was capable of addressing some limitations of the first study. Study 1 was limited in confirming that the participants could detect the race of each hand without being asked explicitly to make that distinction. However, in Study 2 it was made explicit to the participants that they were competing with those that were wearing the opposing color wrist band. Next, Study 1 did not involve any competition, which may be an important input in the regulation of the mu rhythm. In fact, the second study demonstrated that even when participants were made aware of their group membership in relation to the hands performing actions, and when competition is introduced, the mu rhythm is still not regulated by the coalition detecting and tracking mechanism.

Additional findings involve a negative correlation between empathic concern and the allocation bias. This suggests that those participants with higher self-reports of empathy showed less of a bias in allocating resources to an opposing coalition. Next, the ATB, often considered a measure of self-reported prejudice towards Blacks positively correlated with the IRI subscales of empathic concern, fantasy scale, and perspective taking. This finding was not hypothesized, but it certainly makes sense that the more an individual is able to imagine being in another person's position, the less prejudice they would have, regardless of the outgroup (Galinksy & Moskowitz, 2002). Next, a positive correlation was found between the ATB and the mu group bias. This would suggest that the less self-reported prejudice, mu desynchronization for the ingroup was larger relative to the outgroup. This certainly was not hypothesized, rather a negative correlation would

be expected based on the theoretical information motivating the study. Finally, the ATB and resource allocation bias were found to be negatively correlated. There was not a clear hypothesis regarding the relationship between the ATB and allocation biases. However, it could be that the ATB was reflecting, at least in part, attitudes of group equality (Brodish, Brazy, & Devine, 2008). In sum, neither hypothesis was confirmed, yet additional limitations, future directions, and a re-examination of the functional properties of the mu rhythm are in order.

General Discussion

Research has discovered that humans are often slower to recognize the face and emotional expressions of their racial outgroups (e.g., Hugenburg & Bodenhausen, 2004). Additional findings suggest that this effect holds true for any outgroup (Weisbuch & Ambady, 2008; Brown et al., 2006) or coalition (Kurzban et al., 2001; Mondillon et al., 2007). Adolphs et al. (2000), Enticott et al. (2008), and Niedenthal et al. (2005) In fact, a necessary antecedent to recognizing facial expressions is the automatic and often subtle mimicking of the expression by the perceiver (Adolphs et al., 2000; Enticott et al., 2008; Niedenthal et al., 2005) which increases likeability and cooperation (Chartrand & Bargh, 1999; Lakin & Chartrand, 2003; Van Baaren et al., 2004) even in virtual environments (Bailenson & Yee, 2005). Despite this wealth of research, a causal link between the cognitive mechanism that detects and tracks coalitions and the cognitive mechanisms that produce imitation and face mimicry is missing. A likely candidate is reflected in the psychophysiological phenomenon called the mu rhythm, considering it has been implicated in imitation (Oberman et al., 2005; Muthukumaraswamy & Johnson, 2004),

increased social interaction (Oberman et al., 2007), and empathy for pain (Yang et al., 2009). The goal of the current research was to provide evidence demonstrating that the cognitive mechanisms that detect and track coalitions, store parameters regarding a perceived individual that regulate the mu rhythm, which in turn has the ability to alter face mimicry, imitation, likeability, and cooperation.

In Study 1, White participants viewed goal-directed actions performed by Black and White male hands while EEG recorded their mu rhythm desynchronization. The results revealed that there was no significant difference in mu rhythm desynchronization based on race, suggesting that the coalition mechanism underlying race categorization did not regulate the mu rhythm. One limitation from this study is that it was not made explicit that the hands represented racial ingroups and outgroups. Moreover, this initial study did not involve the participants in a competitive situation between groups, a potentially important factor considering the role of imitation in cooperation and resource allocation (Lakin & Chartrand, 2003).

The second study attempted to address these limitations while simultaneously testing the initial hypothesis again. In Study 2, participants were randomly assigned to one of two teams based on the minimalist group paradigm (Tajefel, 1970) and the coalition manipulation (Kurzban et al., 2001). Participants viewed goal-directed actions performed by individuals on their team or on their opposing team, both of which contained an equal number of White and Black hands. Participants were explicitly told that they were competing against the opposing team for a monetary reward. The results indicated that the coalition mechanism did not regulate the mu rhythm, even when the

coalitions are made explicit *and* a competitive scenario was established.

Methodological Limitations

The first methodological limitation in both studies was the small sample size and the uneven distribution of male and female participants. In the first study only eighteen participants' data were analyzed. Of the eighteen participants twelve were female and seven were male. In the second study data were analyzed from twenty-nine participants, however, nine were females and twenty were males. In the first study, a larger sample size would likely reduce the variability, but in terms of EEG research, this is a typical sample size. The most important concern with both sample sizes was that participant sex differences could not be examined. In fact, Yang et al. (2009) found significantly more mu desynchronization for female participants when viewing a hand in a painful situation, and other research has discovered that males tend to show more explicit race biases, exhibit larger biases in resource allocation, and aggress more towards outgroups than females (Navarrete, McDonald, Molin, & Sidanius, 2010). These results suggest that if there is regulation of the mu rhythm by a coalition mechanism, male participants may show a more pronounced effect than female participants.

A second limitation specific to the second study is concerned with the group manipulation. Participants were arbitrarily assigned to either the red or blue team based on a fictitious perceptual task, and told they would compete with the opposing team to determine how to allocate a $200 prize. First, it is possible that this manipulation did not provide enough of the inputs necessary to generate a sense of belonging to one group. Second, the $200 prize may not have been large enough to provide a competitive context.

Third, the participants were told they would merely decide how the prize would be allocated between the two teams, not to themselves personally. Although these are possible limitations, the procedure of this study followed Tajfel's (1970) minimalist group paradigm which has demonstrated in multiple studies that simply placing participants in one group and having them allocate resources to the team, not the individual, is enough to elicit group biases.

The last methodological limitation is concerned with demonstrating a causal link. Although these studies failed to demonstrate the regulation of the mu rhythm by the coalition mechanism, if it had, there were not any measures of imitation or mimicry. The only behavioral measure existed in Study 2 as the differential allocation of resources, yet it has not been demonstrated that the mu rhythm is a necessary antecedent to this particular behavior. Although other researchers have discovered a causal role for mu rhythm desynchronization and imitation (Oberman et al., 2005), it is not clear if the parameters stored by the coalition mechanism would regulate the mu rhythm such that imitation would be affected. Future investigations should take this in to consideration by designing experiments in which imitation or face mimicry behavior can be measured while simultaneously recording mu rhythm desynchronization. For example, a study using facial electromyography (EMG) to measure facial muscle movement coupled with EEG would allow for such a test.

Theoretical Concerns

An important theoretical question that the current studies highlights is whether visual cues derived solely from an arm and hand of an individual are enough to engage

the coalition mechanism. The majority of research on race-related biases has used face stimuli (e.g., Dickter & Bartholow, 2007); although the consensus in the scientific community is that any visually prominent feature should elicit the categorization by race (Fiske et al., 1999) or coalition (Kurzban et al., 2001). In fact, pilot tests revealed that perceivers were easily able to categorize the race of the actors through visual inspection of their hands in the videos, although it is unknown whether this categorization occurred unprompted in the two studies reported here.

Similarly, the participants viewed hands performing goal-directed actions, but these actions were not necessarily related to the competition. This raises an important concern regarding the mu rhythm. It is typically suggested that the mu rhythm is only sensitive to goal-directed actions (Ulloa & Pineda, 2007), yet the specific goal of an action in conjunction with the current context has not been studied. It is possible that if the coalition mechanism were to regulate the mu rhythm, it would do so in a functionally meaningful way, such that only actions that are relevant to the relationship between the established coalitions would have an effect. Perhaps in a competitive context, only goal-directed actions indicative of cooperation would elicit more mu rhythm desynchronization. Theoretical support for this notion would come from the domain-specific view of the brain/mind that comprises one of the major principles of an evolutionary psychology approach.

The next theoretical concern shifts the focus to the coalition mechanism. Kurzban et al. (2001) demonstrated that by correlating shared visual cues and cues of allegiance, conceptualizations of coalitions were maximized. Similarly, Tajfel's (1970) minimal

group paradigm has shown the least amount of input required to generate a conceptualization of a coalition. It seems quite plausible that additional functionally relevant variables (e.g. competition for resources, threat of bodily harm) would regulate the conceptualization of a coalition appropriately. For example, imagine the coalitions formed when two athletic teams compete in comparison to the coalitions formed by ethnic groups in various regions of the world. Even within athletics the difference in the coalitions formed when two "rivals" compete appears, anecdotally anyway, much stronger than non-rivals. This suggests an additional avenue of research investigating moderating input variables during coalition formation. With respect to the mu rhythm, it is possible that only moderate to strong coalition affiliations are capable of regulating its desynchronization.

Lastly, the results from these studies encourage a re-examination of the function of the mu rhythm. Pineda (2005) has suggested that the mu rhythm functions as an action observation/execution matching system, or as translating "seeing" or "hearing" into "doing". In other words, Pineda (2005) suggests that the mu rhythm functions as the center of embodied simulation. However accurate Pineda's (2005) "functional" explanation for the mu rhythm, it is merely a description, and a general one at that. It does not serve to guide *specific* hypotheses, and the hypotheses that are derived from this explanation can simply be derived from the embodied cognition literature as a whole. In addition, Pineda (2005) does more to *describe* the mu rhythm than to actually *explain* its function. From an evolutionary approach, the "functioning" of a mechanism is "the problem it solved -- the consequences it had -- that caused the propagation of its genetic

basis relative to that of alternative mechanisms" (Ermer et al., 2007, p. 153). Following this definition, it is not clear *precisely* what problem an action observation/execution matching system would solve. Indeed, such a system would solve *many* problems, making it a too general from a computational standpoint to be considered an adaptation. This would leave the understanding of the mu rhythm to be just as ambiguous and unpredictable without Pineda's (2005) definition. Before future research investigates what variables influence the desynchronization of the mu rhythm, a comprehensive and evolutionarily informed functional analysis should be conducted.

As a proposed alternative to Pineda's (2005) conceptualization of the mu rhythm, it seems plausible that the mu rhythm simply reflects a *feature* that any number of domain-specific, content-dependent cognitive mechanisms possess. In comparison to this conceptualization, consider what problem attention or memory solved over evolutionary time. It is likely that attention and memory both solved *many* problems (i.e. attending to threats, faces, cues regarding mate value, etc.). Likewise, many domain-specific cognitive mechanisms would only be able to solve their own *specific* adaptive problem if they had the features of attention and memory. For example, the cognitive mechanisms that detect cheaters initially use conditional logic to detect a cheater (Cosmides, 1989). However, what use is detecting whether another person is going to take your resources if you cannot remember this person at a later date? Research on this topic has in fact revealed that humans find cheaters more important to remember than cooperators, and even more so when there is a greater amount of resources at stake (Chiappe, 2004). Behaviorally, humans look longer and have enhanced memory for faces of individuals that had

previously cheated (Chiappe, 2004). From a broader perspective, memories are often stored in the sensory modality in which the initial information acquired (i.e. remembering sounds in auditory cortex; Barsalou, Simmons, Barbey, & Wilson, 2003) suggesting that memory is a *feature* of other mechanisms, not an adaptation in and of itself. In the same way that memory may be a *feature* of many domain-specific content-dependent cognitive mechanisms shaped by natural selection to solve recurring adaptive problems, so too are the neuro-computations generating the mu rhythm. Instead of storing information for future use (e.g. memory), the neuro-computations generating the mu rhythm are converting the stored parameters from various cognitive mechanisms to move the body through the world in adaptive ways on average. This conceptualization of the mu rhythm would inherently encapsulate the embodied view of the brain/mind from an evolutionarily informed perspective, yielding more predictability, driving hypothesis testing.

Conclusion

In conclusion, the hypothesis that the cognitive mechanism responsible for detecting and tracking coalitions would regulate the neuro-computations reflected in the mu rhythm was not supported. These results do question the current conceptualization of the mu rhythm, suggesting that future research may benefit by employing more evolutionarily rigorous standards in determining its function. Additionally, research investigating the coalition mechanism may benefit from considering moderating variables that may alter the strength of a perceived coalition. Lastly, by combining both an evolutionary framework with an embodied view of the brain/mind, a causal link between

person perception and intergroup conflict may eventually be revealed.

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Table 1. Descriptive Statistics for Self-report Measures in Study 1.

	M	*SD*
Number of Friends	0.06	0.11
Social Contact	3.08	1.4
Interpersonal Experience	3.31	0.7
Attitudes Towards Blacks	5.81	0.75
Empathic Concern	3.79	0.61
Fantasy Scale	3.69	0.8
Personal Distress	2.51	0.65
Perspective Taking	3.72	0.75

Note. N=18

Means and standard deviations for each subscale. Number of Friends, Social Contact, and Interpersonal Experience are subscales from the familiarity questionnaire. Empathic Concern, Fantasy Scale, Personal Distress, and Perspective Taking are subscales from the Interpersonal Reactivity Index (IRI).

Table 2. Table of Correlations for Study 1.

		1	2	3	4	5	6	7	8
1	Mu Rhythm Bias	-	-	-	-	-	-	-	-
2	Number of Friends	-0.21	-	-	-	-	-	-	-
3	Social Contact	-0.21	-0.04	-	-	-	-	-	-
4	Interpersonal Experience	-0.23	0.23	0.17	-	-	-	-	-
5	Attitudes Towards Blacks	-0.09	0.22	0.35	0.27	-	-	-	-
6	Empathic Concern	0.18	-0.07	0.20	-0.12	0.48*	-	-	-
7	Fantasy Scale	0.54*	-0.23	0.08	-0.20	0.05	0.40	-	-
8	Personal Distress	-0.13	0.24	0.11	0.06	0.26	0.39	-0.08	-
9	Perspective Taking	-0.14	-0.09	-0.07	0.00	-0.08	0.12	-0.03	0.13

Note. * $= P < 0.05$, n=18

Table 3. Descriptive Statistics for Self-report Measures in Study 2.

	M	*SD*
Number of Friends	0.04	0.06
Social Contact	3.44	0.88
Interpersonal Experience	2.95	0.84
Attitudes Towards Blacks	5.76	0.79
Empathic Concern	3.68	0.61
Fantasy Scale	3.55	0.89
Personal Distress	2.41	0.62
Perspective Taking	3.48	0.81

Note. N=18

Means and standard deviations for each subscale. Number of Friends, Social Contact, and Interpersonal Experience are subscales from the familiarity questionnaire. Empathic Concern, Fantasy Scale, Personal Distress, and Perspective Taking are subscales from the Interpersonal Reactivity Index (IRI).

Table 4. Table of Correlations for Study 2.

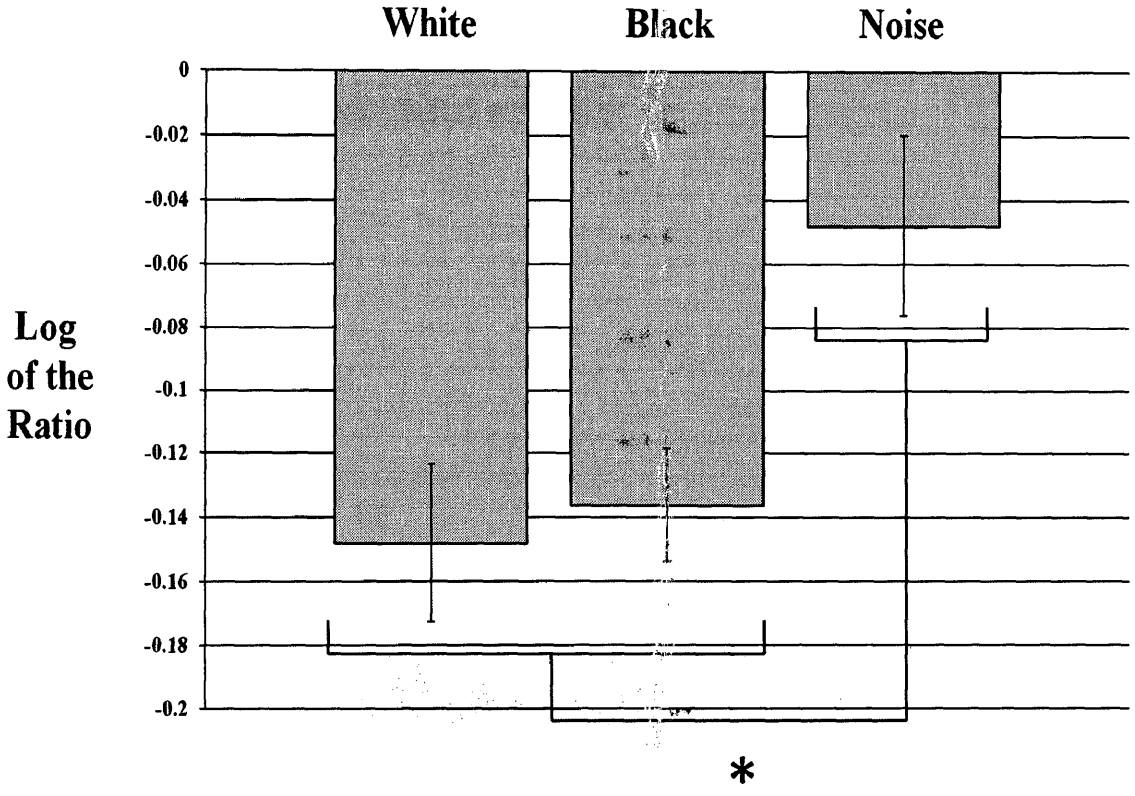
		1	2	3	4	5	6	7	8	9
1	Mu Group Bias	-	-	-	-	-	-	-	-	-
2	Allocation Bias	-0.04	-	-	-	-	-	-	-	-
3	Number of Friends	0.20	-0.25	-	-	-	-	-	-	-
4	Social Contact	-0.02	-0.31	0.38*	-	-	-	-	-	-
5	Interpersonal Experience	0.19	-0.21	0.50**	0.54**	-	-	-	-	-
6	Attitudes Towards Blacks	0.43*	-0.52**	0.24	0.22	0.41*	-	-	-	-
7	Empathic Concern	0.37*	-0.37*	0.26	0.16	0.35	0.60**	-	-	-
8	Fantasy Scale	0.20	-0.33	-0.05	-0.14	0.08	0.52**	0.36	-	-
9	Personal Distress	-0.06	-0.08	0.03	0.28	0.08	0.13	-0.13	0.03	-
10	Perspective Taking	0.30	-0.09	0.08	0.34	0.41*	0.44*	0.58**	0.12	-0.13

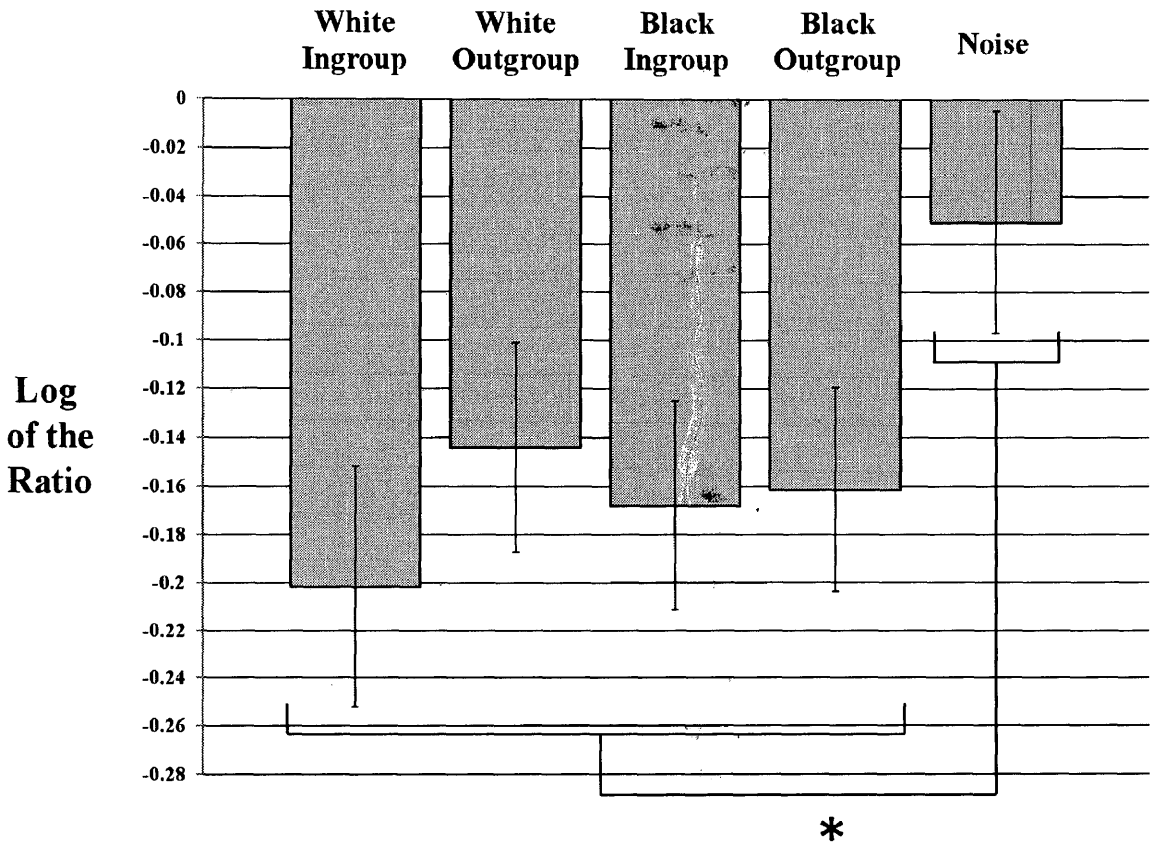
Note. * $= P < 0.05$, ** $= P < 0.01$, n=29

Figure Captions

Figure 1. Bar graph representing the mean and standard error of the log of the ratio of mu desynchronization for each of the three conditions. The asterisk represents the first planned contrast that demonstrated significantly more desynchronization of the average of the White and Black condition relative to the noise condition, N=18.

Figure 2. Bar graph representing the mean and standard error of the log of the ratio of mu desynchronization for each of the five conditions. The asterisk represents the first planned contrast that demonstrated significantly more desynchronization of the average of the White ingroup, White outgroup, Black ingroup, and Black outgroup condition relative to the noise condition, N=29.


White
Black
Noise
Log of the Ratio
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
-0.2
*


White Ingroup
White Outgroup
Black Ingroup
Black Outgroup
Noise
Log of the Ratio
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
-0.2
-0.22
-0.24
-0.26
-0.28
*

Appendix A

Interpersonal Reactivity Index (IRI).

INTERPERSONAL REACTIVITY INDEX

The following statements inquire about your thoughts and feelings in a variety of situations. For each item, indicate how well it describes you by choosing the appropriate letter on the scale at the top of the page: A, B, C, D, or E. When you have decided on your answer, fill in the letter next to the item number. READ EACH ITEM CAREFULLY BEFORE RESPONDING. Answer as honestly as you can. Thank you.
ANSWER SCALE:

1	2	3	4	5
Does Not Describe Me Very Well				Describes Me Very Well

1. I daydream and fantasize, with some regularity, about things that might happen to me. (FS)
2. I often have tender, concerned feelings for people less fortunate than me. (EC)
3. I sometimes find it difficult to see things from the "other guy's" point of view. (PT)(-)
4. Sometimes I don't feel very sorry for other people when they are having problems. (EC) (-)
5. I really get involved with the feelings of the characters in a novel. (FS)
6. In emergency situations, I feel apprehensive and ill-at-ease. (PD)
7. I am usually objective when I watch a movie or play, and I don't often get completely caught up in it. (FS) (-)
8. I try to look at everybody's side of a disagreement before I make a decision. (PT)
9. When I see someone being taken advantage of, I feel kind of protective towards them. (EC)
10. I sometimes feel helpless when I am in the middle of a very emotional situation. (PD)
11. I sometimes try to understand my friends better by imagining how things look from their perspective. (PT)
12. Becoming extremely involved in a good book or movie is somewhat rare for me. (FS) (-)
13. When I see someone get hurt, I tend to remain calm. (PD) (-)
14. Other people's misfortunes do not usually disturb me a great deal. (EC) (-)
15. If I'm sure I'm right about something, I don't waste much time listening to other people's arguments. (PT) (-)
16. After seeing a play or movie, I have felt as though I were one of the characters. (FS)
17. Being in a tense emotional situation scares me. (PD)
18. When I see someone being treated unfairly, I sometimes don't feel very much pity for them. (EC) (-)

19. I am usually pretty effective in dealing with emergencies. (PD) (-)
20. I am often quite touched by things that I see happen. (EC)
21. I believe that there are two sides to every question and try to look at them both. (PT)
22. I would describe myself as a pretty soft-hearted person. (EC)
23. When I watch a good movie, I can very easily put myself in the place of a leading character. (FS)
24. I tend to lose control during emergencies. (PD)
25. When I'm upset at someone, I usually try to "put myself in his shoes" for a while. (PT)
26. When I am reading an interesting story or novel, I imagine how I would feel if the events in the story were happening to me. (FS)
27. When I see someone who badly needs help in an emergency, I go to pieces. (PD)
28. Before criticizing somebody, I try to imagine how I would feel if I were in their place. (PT)

NOTE: (-) denotes item to be scored in reverse fashion

PT = perspective-taking scale
FS = fantasy scale
EC = empathic concern scale
PD = personal distress scale
A = 0
B = 1
C = 2
D = 3
E = 4

Except for reversed-scored items, which are scored:

A = 4
B = 3
C = 2
D = 1
E = 0

Appendix B

Familiarity Questionnaire.

On this paper, please list the initials of up to 20 of your closest friends. You may also list acquaintances. When you are finished, continue to the next page.

Look at your list of your 20 friends/acquaintances that you just generated. Indicate how many of those individuals are Black. _____
Please indicate how much you agree with each of the following statements:

- I often talk to Black people in college.

1	2	3	4	5
strongly disagree	sort of disagree	not sure	sort of agree	strongly agree

- I often see Black people outside of college.

1	2	3	4	5
strongly disagree	sort of disagree	not sure	sort of agree	strongly agree

- I often hang out with Black people.

1	2	3	4	5
strongly disagree	sort of disagree	not sure	sort of agree	strongly agree

Please indicate how often you do each of the following activities.

- How often do you spend time with Black friends at their place?

1	2	3	4	5
never	rarely	once in a while	sometimes	frequently

- How often do you have Black friends over to your place?

1	2	3	4	5
never	rarely	once in a while	sometimes	frequently

- How often have you helped someone Black with a problem they had in class?

1	2	3	4	5
never	rarely	once in a while	sometimes	frequently

- How often have you asked for/received help from someone Black when you had a problem in class?

1	2	3	4	5

never rarely once in a while sometimes frequently

- How often have you given a Black person advice on a personal problem?

1 2 3 4 5
never rarely once in a while sometimes frequently

- How often have you received advice from a Black person when you are having a personal problem?

1 2 3 4 5
never rarely once in a while sometimes frequently

- How often have you comforted a Black person when they were upset or sad?

1 2 3 4 5
never rarely once in a while sometimes frequently

- How often have you been comforted by a Black person when you were upset or sad?

1 2 3 4 5
never rarely once in a while sometimes frequently

- How often have you worked with Black classmates on projects?

1 2 3 4 5
never rarely once in a while sometimes frequently

- How often have you had a Black person on your team during sports or your group during other activities?

1 2 3 4 5
never rarely once in a while sometimes frequently

Appendix C

Attitudes Towards Blacks (ATB).

1. If a Black person were put in charge of me, I would not mind taking advice and direction from him or her.

1	2	3	4	5	6	7
strongly disagree						strongly agree

2. If I had a chance to introduce Black visitors to my friends and neighbors, I would be pleased to do so.

1	2	3	4	5	6	7
strongly disagree						strongly agree

3. I would rather not have blacks live in the same apartment building I live in.

1	2	3	4	5	6	7
strongly disagree						strongly agree

4. I would probably feel somewhat self-conscious dancing with a Black person in a public place.

1	2	3	4	5	6	7
strongly disagree						strongly agree

5. I would not mind it at all if a Black family with about the same income and education as me moved in next door.

1	2	3	4	5	6	7
strongly disagree						strongly agree

6. I think that Black people look more similar to each other than White people do.

1	2	3	4	5	6	7
strongly disagree						strongly agree

7. Interracial marriage should be discouraged to avoid the "who-am-I?" confusion which the children feel.

1 2 3 4 5 6 7

strongly disagree — strongly agree

8. I get very upset when I hear a White person make a prejudicial remark about Black people.

1 2 3 4 5 6 7

strongly disagree — strongly agree

9. I favor open housing laws that allow more racial integration of neighborhoods.

1 2 3 4 5 6 7

strongly disagree — strongly agree

10. It would not bother me if my new roommate was Black.

1 2 3 4 5 6 7

strongly disagree — strongly agree

11. It is likely that Blacks will bring violence to neighborhoods when they move in.

1 2 3 4 5 6 7

strongly disagree — strongly agree

12. I enjoy a funny racial joke, even if some people might find it offensive.

1 2 3 4 5 6 7

strongly disagree — strongly agree

13. The federal government should take decisive steps to override the injustices Blacks suffer at the hands of local authorities.

1 2 3 4 5 6 7

strongly disagree — strongly agree

14. Black and White people are inherently equal.

1 2 3 4 5 6 7

strongly disagree — strongly agree

15. Black people are demanding too much too fast in their push for equal rights.

1 2 3 4 5 6 7

strongly disagree — strongly agree

16. Whites should support Blacks in their struggle against discrimination and segregation.

1 2 3 4 5 6 7

strongly disagree — strongly agree

17. Generally, Blacks are not as smart as Whites.

1 2 3 4 5 6 7

strongly disagree — strongly agree

18. I worry that in the next few years I may be denied my application for a job or a promotion because of preferential treatment given to minority group members.

1 2 3 4 5 6 7

strongly disagree — strongly agree

19. Racial integration (of schools, businesses, residences, etc.) has benefited both Whites and Blacks.

1 2 3 4 5 6 7

strongly disagree — strongly agree

20. Some Blacks are so touchy about race that it is difficult to get along with them.

1 2 3 4 5 6 7

strongly disagree — strongly agree